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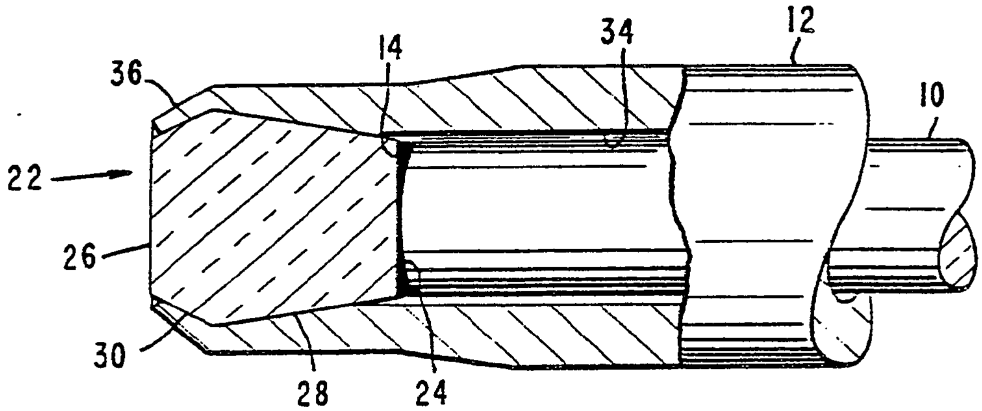
(54) Title: MINIATURE WINDOW FOR OPTICAL FIBER

(57) Abstract

Fiber optic window (22) is conical and is pressed into the tapered open end bore of sheath (12) which contains fiber optic guide (10) for sealing the sheath. Malleable deformation of the sheath provides hermetic sealing. Swaged end of lip portion (36) retains window in place.



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MINIATURE WINDOW FOR OPTICAL FIBER

BACKGROUND OF THE INVENTION

This invention is directed to a miniature window particularly useful for the hermetic closure of the end of a protective sheath around an optical fiber.

U.S. Patent 4,170,997 to Douglas A. Pinnow and Anthony L. Gentile is directed to a medical laser instrument which employs a flexible fiber optical endoscope which is suitable for application of long wavelength, high power laser radiation for surgical purposes inside the human body. To accomplish this purpose, the optical fiber has a sheath which prevents contact between the body fluid and the fiber optic waveguide material which is capable of infrared transmission. When non-refractory optical fibers are used to transmit long wave infrared radiation, it is often necessary to protect them from a hostile environment. For example, fibers of alkali halides, while excellent transmitters of infrared radiation, are very soluble in water and easily corroded by moisture. It is thus necessary to protect such fibers against body fluids. Alternate fiber materials such as thallium halide compounds are toxic, and thus the body and the remainder of the exterior environment must be protected from exposure to the noxious fiber material. In either case, it becomes necessary to surround the fiber with a hermetic protective sheath while providing a means for the radiation to enter or emerge at the end of the fiber.

SUMMARY OF THE INVENTION

In order to aid in the understanding of this invention it can be stated in essentially summary form that it is directed to a miniature window plug which is sealed in the end of a tubular malleable sheath for an optical fiber. The window has a conical outer surface which causes malleable outward deformation of the sheath during insertion of the window into the end of the sheath to provide hermetic sealing of the internal volume of the bore of the sheath. The window is transparent to the optical frequency employed.

It is thus an object of this invention to provide a hermetically sealed miniature window and particularly a window assembly suitable for use with very small optic fiber malleable sheaths.

It is another object to provide a method for the hermetic installation of a substantially transparent window plug in the end opening of an optical fiber malleable sheath.

Other objects and advantages of this invention will become apparent from a study of the following portion of the specification, the claims and the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevational view of an optical fiber sheath with a miniature window plug therein in accordance with this invention, with parts broken away and parts taken in central section.

FIG. 2 is a side elevational view of the structure before insertion of the window plug into the end of the bore of the optical fiber sheath.

FIG. 3 is a side elevational view, with parts broken away and parts taken in section of the end of the fiber optic sheath, after insertion of the miniature window therein and before final sealing.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In the preferred embodiment, optical fiber 10 is substantially transmissive to long wave infrared radiation, and many such fibers are soluble in water, easily corroded by moisture or are toxic. Examples of suitable alkali halide fibers which are soluble include sodium chloride, potassium chloride and potassium iodide. Examples of toxic fibers are thallium halides, including thallium bromoiodide also known as KRS-5 and thallium bromide. In order to protect the optical fiber 10 against its environment and to protect the environment against the optical fiber 10, sheath 12 is provided.

Sheath 12 is a malleable tubular metallic sheath, for example, a 24 gauge stainless steel or platinum syringe needle tube. Optical fiber 10 is placed therein, with its end 14 recessed with respect to the end 16 of the sheath.

The external surface of sheath 12 is tapered down toward the end 16 to form a right conical surface 18 about the central axis 20 of the entire structure. The conical shaping of the end of the sheath reduces the wall thickness but stops short of forming a knife edge at end 16.

Window 22 is a structure which is transparent to the wavelength of interest. For infrared radiation, window 22 can be made of diamond, germanium, zinc selenide or silicon. Window 22 is also a surface of revolution about the axis 20. It has inner and outer planar ends 24 and 26, both normal to the axis 20. The outer surface of window 22 is comprised of a first right conical surface 28 and a second right conical surface 30. Both of these right conical surfaces are surfaces of revolution about axis 20. The first conical surface 28 is at the same conical angle as the original conical surface 18 on the exterior of sheath 12, as seen in FIG. 2. The truncated diameter

of conical surface 28 adjacent the inner planar end 24 is the same as the diameter of the bore 34 of sheath 12.

As is seen in FIGS. 2 and 3, window 22 is first placed adjacent the open end of sheath 12 and then the conical surface 28 is forcibly inserted into the open end of sheath 12. Thrust of the window 22 into the malleable sheath 12 causes expanding deformation of the sheath so that when the window is fully inserted as is illustrated in FIG. 3, the entire conical surface 28 is in hermetic sealing contact with the sheath. The residual deformation stress causes continued compression of the sheath onto the window on conical surface 28.

In order to retain window 22 in place, the end portion or lip 36 of the sheath extending over the surface 30 is swaged down onto the surface 30. With the window deforming the bore of the sheath, a hermetic seal is formed, and the window is locked in place by the inwardly swaged end portion of lip 36.

As an aid toward pressing window 22 into the bore, the total included angle of conical surface 28 was chosen to be 20°, but alternate angles can be employed, as required by the malleability characteristics of sheath 12.

As stated above, suitable materials for window 22 include diamond, germanium and zinc selenide and silicon. These materials have essentially no solubility in fluids with which they might come in contact in a human body. All these materials have good transparency in the long wavelength part of the infrared spectrum. All these materials have a large refractive index and thus it is advantageous to provide the window 22 with an anti-reflection coating to maximize transmission. The coating on facet 24 may be any standard coating. However, the coating on facet 26 is exposed to body fluids and must be inert. A multi-layer

coating such as barium fluoride-zinc selenide will be reasonably resistant to such exposure.

This invention has been described in its presently contemplated best mode and it is clear that it is susceptible to numerous modifications, modes and embodiments within the ability of those skilled in the art and without the exercise of the inventive faculty. Accordingly, the scope of this invention is defined by the scope of the following claims.

CLAIMS

What is Claimed is:

1. An optical fiber assembly comprising:

an elongated optical fiber having ends;

a sheath surrounding said optical fiber adjacent at least one end thereof, said sheath being tubular with a bore therein and being made of malleable material, said sheath bore being divergent adjacent the end of said sheath; and

a window within said sheath adjacent said end of said optical fiber, said window having a convergent surface engaged against and within said divergent surface of said sheath bore to plug the end of said tubular sheath, said window being at least partially transparent to radiation of the same wave-length to which said optical fiber is at least partially transparent.

2. The optical fiber assembly of Claim 1 wherein said window and said fiber are at least partially transparent to radiation in the infrared wavelength band.

3. The fiber optic assembly of Claim 1 wherein said divergent bore of said sheath and said convergent surface of said window are conical surfaces of revolution about an axis coaxial with the axis of the fiber.

4. The fiber optic assembly of Claim 3 wherein said axis is substantially centrally positioned through said optical fiber and said sheath.

5. The optical fiber assembly of Claim 4 wherein said window and said fiber are at least partially transparent to infrared in the long wavelength infrared band ranging from 8 to 30 micrometers wavelength.

6. The fiber optic assembly of Claim 4 wherein the divergent bore of said sheath is engaged on the convergent external surface of said window for retaining said window within said sheath and for retaining said convergent surface of said window against said divergent bore surface within said sheath.

7. The fiber optic assembly of Claim 1 wherein said sheath is engaged on said window to retain said window within said sheath and retain said convergent surface of said window against said divergent bore surface within said sheath.

8. The fiber optic assembly of Claim 7 wherein said convergent surface on said window is conical and said window also has a divergent conical surface thereon, said sheath engaging on said divergent surface to retain said window within said sheath.

9. The method of attaching a window plug having a divergent surface within the end of a malleable tubular sheath having an optical fiber therein comprising the step of:

pressing the window conical end first into the open bore of said tubular sheath so that the conical surface on said window malleably outwardly forms the sheath to produce a resilient hermetic sealing engagement of said sheath onto said window.

10. The method of Claim 9 further including the step of plastically deforming the overhanging lip of said tubular sheath around the periphery of the window outwardly of said divergent surface to retain and lock the window within the sheath.

Fig. 2.

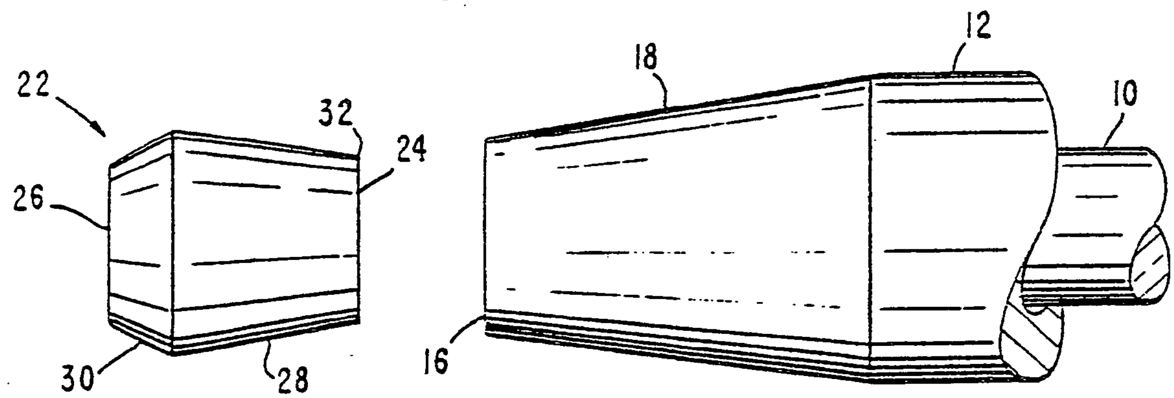
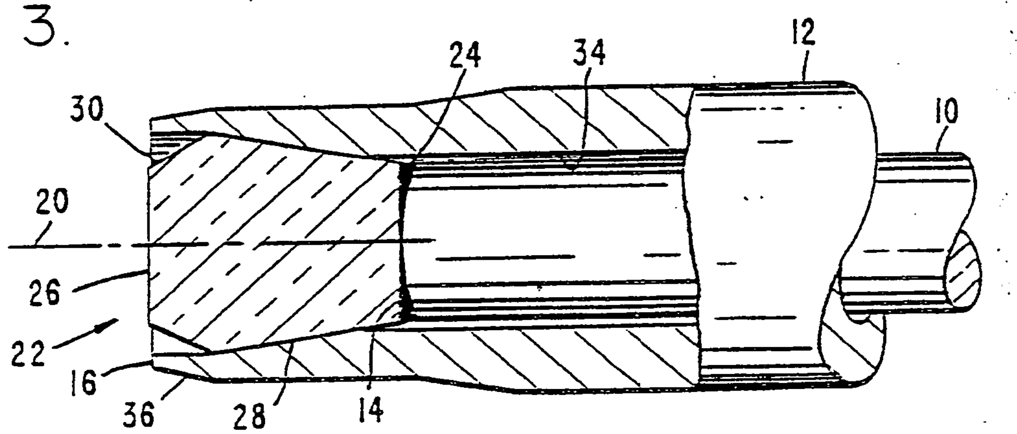


Fig. 3.



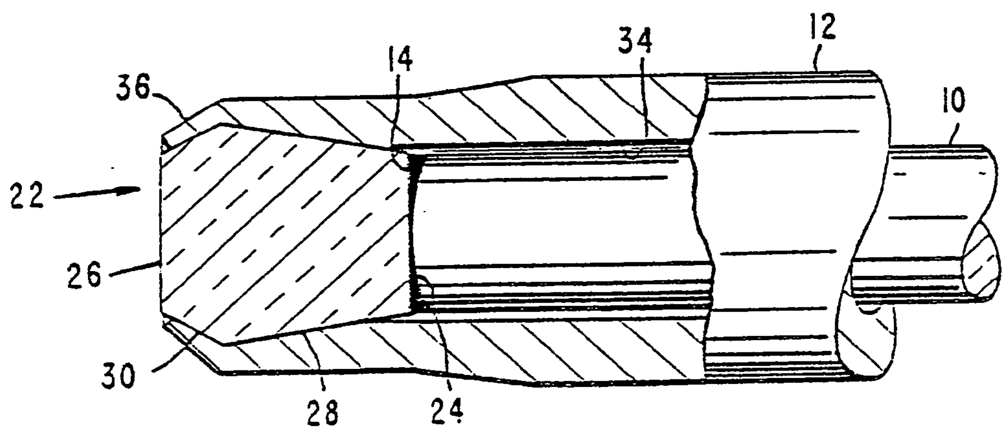


Fig. 1.

INTERNATIONAL SEARCH REPORT

International Application No PCT/US82/00048

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC

INT. CL.3 G02B 7/26; A61N 5/06
U.S. CL. 350/96.20; 128/398

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
U.S.	128/4,5,6,303.1,395,396,397,398; 350/96.20,96.25, 96.26

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [5]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
X	GB, A, 1,234,958, PUBLISHED 09 JUNE 1971, BRET, SEE ESPECIALLY ELEMENTS 2 AND 2'	1-10
A	US, A, 3,809,072, PUBLISHED 07 MAY 1974, ERSEK ET AL.	1-10
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P,A	US, A, 4,266,549, PUBLISHED 12 MAY 1981, KIMURA	1-10
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"X" document of particular relevance

IV. CERTIFICATION

Date of the Actual Completion of the International Search [2]	Date of Mailing of this International Search Report [2]
05 MAY 1982	11 MAY 1982
International Searching Authority [1]	**Signature of Authorized Officer [10]**
ISA/US	John D. Lee John D. Lee

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